Substituting and rearranging terms in (6) gives;

$$V^2 = \frac{(300)}{480}\frac{(1.64)}{\pi^2}\frac{(300)^2}{}\ \frac{E^2}{F^2}$$

$$V^2 = 9346.88\ \ E^2/F^2$$

$$V = \frac{96.68}{F}\ E \tag{7}$$

Converting to db and rearranging gives;

$$20 \log_{10} E = 20 \log_{10} V - 20 \log_{10} \frac{96.68}{F}$$

E db/luv/m = V db/luv - Dipole Factor

The dipole factor is defined as the term

$$20 \log 10 \left[\frac{96.68}{F}\right]$$

A P P E N D I X   B

Fading Ratios

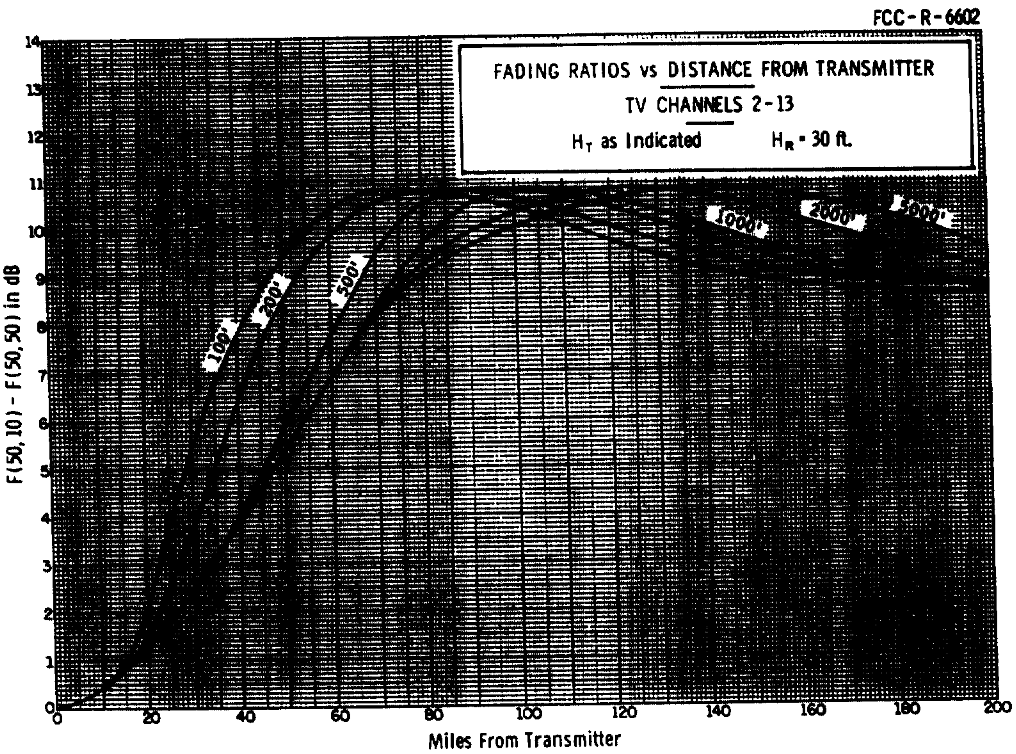

FIGURE 10

A P P E N D I X   C

Receiver Noise Figures

Noise Figures db

Receiver No.	Ch 2	Ch 6	Ch 7	Ch 13
1	5.3	8.7	6.8	5.4
2	9.1	8.9	8.5	9.0
3	4.0	5.0	7.5	7.8
4	7.7	6.7	8.3	9.5
5	6.1	8.2	10.9	10.0
6	5.5	5.2	6.3	7.7
7	5.8	4.8	6.7	6.9
8	7.0	6.5	6.8	7.6
9	4.9	3.3	4.6	6.5
10	6.5	5.1	7.5	6.3

The average for channels 2 & 6 is 6.2 db.

The average for channels 7 & 13 is 7.5 db.

APPENDIX D

Time Probability Factors

The time probability factor, R(T=90), is found by subtracting the field exceeded for 50% of the time from the field exceeded for 90% of the time.

$$R(T{=}90) = F(50,90) - F(50,50)$$

Since the fields are normally distributed, R(T=90) is numerically equal but opposite in sign to R(T=10). The F(50,90) field can therefore be derived from the F(50,50) fields and the fading ratios for 10% of the time. The developments of the F(50,90) curves for channels 2-6 and 7-13 are shown in tables D1 and D2 below.

The F(50,50) values are from figures 9 and 10, Part 73.699 of the FCC Rules and Regulations. The values for R(T=10) are from the curves of Appendix B.

TABLE D1

CHANNELS 2-6

Dist. Miles	F(50,50) 1000 ft.	F(50,50) 2000 ft.	R(T = 10) 1000 ft.	R(T = 10) 2000 ft.	F(50,90) 1000 ft.	F(50,90) 2000 ft.
10	72	78	.4	.4	71.6	77.6
15	65	71.5	.8	.8	64.2	70.7
20	59.5	66.2	1.3	1.3	58.2	64.9
25	55	62	1.8	1.8	53.2	60.2
30	51	58.5	2.5	2.5	48.5	56.0
35	47.2	55	3.2	3.2	44.0	51.8
40	43.6	51.5	3.9	3.9	39.7	47.6
45	40	48.2	4.6	4.6	35.4	43.6
50	36.7	45	5.4	5.4	31.3	39.6
55	33	41.7	6.6	6.6	26.4	35.1
60	30	38.5	6.9	6.9	23.1	31.6
65	26.7	35.5	7.6	7.6	19.1	27.9
70	23.9	32.5	8.4	8.3	15.5	24.2
75	21.2	30	9.1	8.8	12.1	21.2
80	18.9	27	9.6	9.3	9.3	17.7

For Grade A

F(50,90) 1000ft = 46 db - 20 dbkw = 26 db $\therefore$ R(T=90) = 6.6 db

F(50,90) 2000ft = 46 db - 20 dbkw = 26 db $\therefore$ R(T=90) = 8 db

For Grade B

F(50,90) 1000ft = 36 db - 20 dbkw = 16 db $\therefore$ R(T=90) = 8.3 db

F(50,90) 2000ft = 36 db - 20 dbkw = 16 db $\therefore$ R(T=90) = 9 db

TABLE D2

Channels 7-13

Dist. Miles	F(50,50) 1000 ft.	F(50,50) 2000 ft.	R(T = 10) 1000 ft.	R(T = 10) 2000 ft.	F(50,90) 1000 ft.	F(50,90) 2000 ft.
10	75	80	.4	.4	74.4	79.6
15	68	75.4	.8	.8	67.2	74.6
20	62.5	71	1.3	1.3	61.2	69.7
25	58	66.7	1.8	1.8	56.2	64.9
30	54.2	63	2.5	2.5	51.7	60.5
35	50	58.7	3.2	3.2	46.8	55.5
40	46	55	3.9	3.9	42.1	51.1
45	42	51.2	4.6	4.6	37.4	46.6
50	38	47.8	5.4	5.4	32.6	42.4
55	34	44.2	6.6	6.6	27.4	37.6
60	30.7	41	6.9	6.9	23.8	34.1
65	27	37.6	7.6	7.6	19.4	30.0
70	24	34	8.4	8.3	15.6	25.7
75	21	31.3	9.1	8.8	11.9	22.5
80	18.9	28	9.6	9.3	9.3	18.7

For Grade A

F(50,90) 1000ft = 57 db - 25 db/Kw = 32 db $\therefore$ R(T = 90) 1000ft = 5.5 db

F(50,90) 2000ft = 57 db - 25 db/kw = 32 db $\therefore$ R(T = 90) 2000ft = 7.3 db

For Grade B

F(50,90) 1000ft = 47 db - 25 db/kw = 22 db $\therefore$ R(T = 90) 1000ft = 7.3 db

F(50,90) 2000ft = 47 db - 25 db/kw = 22 db $\therefore$ R(T = 90) 2000ft = 8.9 db

A P P E N D I X   E

COMPARISON OF TV CHANNEL OFFSET FREQUENCIES: ZERO OFFSET AND 10,010 Hz (PRECISE) OFFSET (PROJECT NO. 2229-73)

Addenda to the Report

1. In the discussion under the heading "Interference Observations", on page 4, the second paragraph has the following footnote added:

   "In the earlier tests conducted by RCA, & others the observer was only asked to indicate when the second picture was of equal quality to the reference picture, as the desired to undesired ratio was changed."

2. The first paragraph on page 12 is changed to read as follows:

   "Another point to keep in mind is that these data were obtained with only one undesired co-channel signal. Work at the Laboratory in 1956 in conjunction with Project No. 2229-26, "Offset Frequencies for TV Emissions," indicated that additional protection of the order of 4 dB is needed when an additional co-channel signal of approximate equal strength is present with a precise offset of 10,010 Hz from the desired signal and 20,020 Hz from the other undesired co-channel signal.*"

FEDERAL COMMUNICATIONS COMMISSION

LABORATORY DIVISION

COMPARISON OF TV CHANNEL OFFSET FREQUENCIES: ZERO OFFSET AND 10,010 HZ (PRECISE) OFFSET
PROJECT NO. 2229-73

June, 1976

SUMMARY

Judgements were made by twelve observers on the comparative picture quality displayed on thirty-five contemporary TV receivers for precise (10,010 Hz) offset and for zero (~0HZ) offset co-channel TV signals. The reference display was that resulting from co-channel TV signals separated by 10,040 Hz, a worst case condition under our present standards. For precise (10,010 Hz) offset, a desired to undesired ratio of 22 dB was judged statistically equivalent to the 28 dB of the reference, a 6 dB improvement. Zero offset was found to offer no improvement, requiring 28 dB D/U for picture quality equal to that from the 28 dB reference, again on a statistical basis.

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COMPARISON OF TV CHANNEL
OFFSET FREQUENCIES: ZERO OFFSET
AND 10,010 HZ (PRECISE) OFFSET
PROJECT NO. 2229-73

INTRODUCTION

The Laboratory Division's responsibility for tests relevant to the effects of TV channel offset frequencies was mentioned in an Inter-Office memorandum, "Special studies relevant to the VHF drop-in proceeding," to Mr. John M. Taff et al from Chief, Research & Standards Division, April 2, 1976. A preliminary demonstration of TV reception under various simulated conditions was given on May 7 for several FCC staff members.

This report deals with the tests involving conditions recognized to be of most interest with regard to TV channel offset frequencies: zero frequency offset, 10,010 Hz (precise) offset, and 10,040 Hz, the latter being an offset frequency representing a "worst case" under present frequency assignment tolerances. A concurrent test of low frequency (~360Hz) very precise offset, Laboratory Project 2229-26, Part II, was not made because of the urgent need for immediate data on the conditions chosen.

Selection of Television receivers

Previous experience with observations of this type, as well as the demonstration given on May 7 to several FCC staff members, indicated that picture quality for offset conditions varies from receiver to receiver. Thus it was decided to employ thirty-five of the TV receivers available at the Laboratory. Thirty-three of the receivers were obtained about four years ago in connection with studies of the UHF taboos. The other two receivers were obtained more recently. A brief description of the types of receivers represented in the tests follows:

I. 25 color TV receivers

   A. 6 with VHF varactor tuners and transistor or IC IF strips

   B. 13 with transistor VHF tuners and transistor or IC IF strips

   C. 4 with tube type VHF tuners and transistor IF strips

   D. 2 with tube type VHF tuners and tube type IF strips

II. 10 monochrome TV receivers

   A. 3 with transistor VHF tuners and transistor IF strips

   B. 7 with tube type VHF tuners and tube type IF strips

Selection of observers

Twelve employees of the Laboratory Division, five women and seven men, served as observers for these tests. By age group, about half of the people were young (18-30) and about half were middle-aged (30-50). Only one of the observers was knowledgeable with regard to the technical aspects of the tests. The observers' questions were answered responsively, but educating the observers was deliberately avoided to enhance the freshness of the observations, a process furthered by other features of the test.

Description of the test signals

The test signals were complete color television signals of broadcast quality in the respects believed necessary for these co-channel tests. Channel 3 was used since this channel is not used in our Washington-Baltimore area and therefore the receivers were not subject to extraneous TV fields in this frequency segment.

As indicated by Figure 1, and described below, two co-channel television signals with modulation obtained from two different off-the-air color television signals were supplied to the television receiver being observed. One of these signals, the desired, was at a level of about -40 dBm, well above the level at which receiver noise would be apparent. The other signal, undesired, was either

(1) the reference condition, a stable venetian blind pattern resulting from a frequency of 10,040 Hz and at a level which was -28 dB with respect to the "desired" signal, or

(2) the test condition, offset in frequency by 10,010 Hz, or by zero hertz, and at a level established in pseudorandom sequence.

A block diagram of the test set-up is shown in Figure 1 and should be referred to in relation to the following brief discussion of the desired and undesired signal chains:

A. Desired Signal Chain

1. The 30.625 MHz signal from an HP 5100A Synthesizer was doubled in the Megapix to produce an accurate 61.250 MHz, Channel 3 visual carrier. The Megapix's internal crystal oscillator produced a nominal 65.75 MHz aural carrier, Channel 3.

2. The Conrac demodulated an off-the-air TV signal. The resultant video and audio signals modulated the Megapix.

3. The desired TV signal from the Megapix was resistively added to the undesired signal described below, and the output applied, as two Channel 3 TV signals, to the receiver under test.

B. Undesired Signal Chain

1. An HP 5105A Frequency Synthesizer provided the two "test" visual carrier frequencies for zero and for 10,010 Hz offset. An HP 5100B Frequency Synthesizer was the RF source for the reference offset signal. Its output was

VHF CO-CHANNEL TEST SETUP BLOCK DIAGRAM

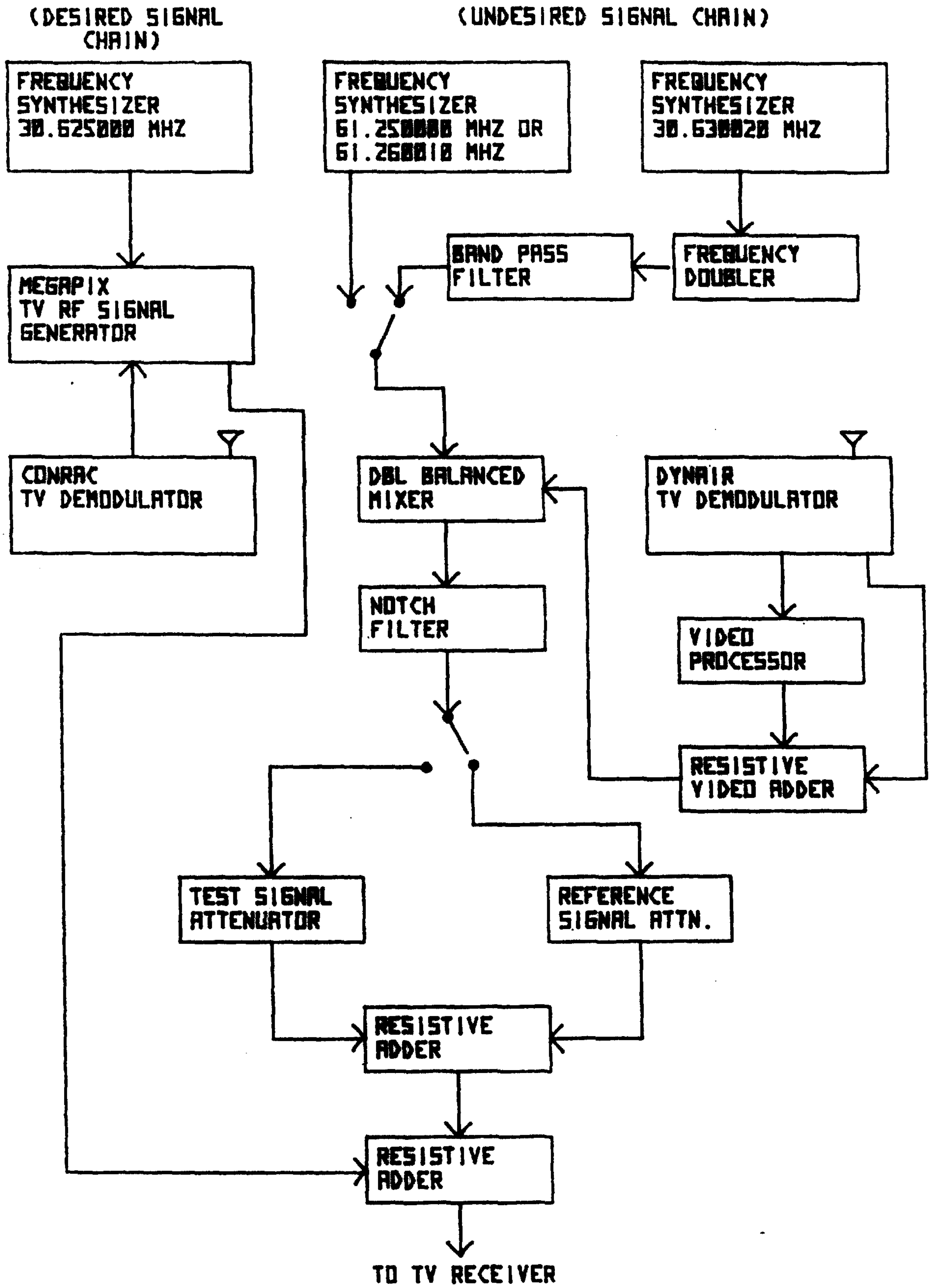


FIGURE 1

doubled and filtered to produce a clean 61.260040 MHz (10,040 Hz offset) visual carrier. These two RF sources selectively fed the double balanced mixer.

2. The Dynair demodulated a second off-the-air TV channel to produce a video signal and an aural 4.5 MHz signal. These signals were combined in a resistive adder and used as modulation for the double balanced mixer. A Tektronic Model 147 was used for dc restoration on the video signal only (Video Processor).

3. The notch filter removed the lower 4.5 MHz aural sideband component produced in the modulation process.

4. The resultant undesired visual and aural components were switched between two variable attenuators. The reference signal attenuator was set for a 28 dB desired to undesired signal ratio. The "test signal" attenuator was varied in 2 dB steps, in a pseudorandom sequence, over an 18 to 32 dB desired to undesired signal ratio.

Interference Observations

Each observer read a copy of the following statement:

"VHF Co-channel Interference Tests

In these tests, you are asked to judge the comparative quality of two TV pictures displayed alternately on the screen of a TV receiver. The one picture will be the reference and it consists of a desired TV signal to which another TV signal has been added. This added signal produces some perceptible interference with the desired signal and therefore impairs its quality.

The second picture contains the same desired video but differs from the reference with respect to the added interference. You are requested to make your own decision as to whether the quality of the second picture is better than, is equal to, or is worse than that of the reference. You are to mark this judgement on the test sheet provided."

Figure 2 shows the test sheet provided to each observer for each five receivers observed. Opposite "REC" the observer wrote the number assigned to the receiver observed. The sixteen test conditions would then be established for that receiver with the observer checking "B" for better than, "E" for equal to, or "W" for worse than the reference condition.

Test conditions 1 through 8 used an undesired signal with its frequency offset 10,010 Hz from the desired. This produces an "interleaved" stationary "venetian blind" pattern, regarded as an optimum condition. Conditions 9 through 16 had the undesired at zero frequency offset with respect to the desired. At the D to U ratio involved, this results in some undesired picture material from the interfering signal, with frame edges kept stable but not coincident with those of the desired picture, and with the respective color burst frequencies apparently equal. Pseudorandom sequences of desired to undesired signal ratios were used and are given in Figure 3, actually a copy of the check sheet used by the person conducting the tests.

VHF CO-CHANNEL TEST

	REC			REC			REC			REC			REC		
	B	E	W	B	E	W	B	E	W	B	E	W	B	E	W
1	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
2	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
3	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
4	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
5	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
6	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
7	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
8	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
9	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
10	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
11	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
12	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
13	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
14	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
15	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
16	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

OBSERVER:______________________

FIGURE 2

#	A	B	C	D	E
1	18	20	30	30	26
2	26	22	28	24	30
3	30	26	22	26	20
4	20	24	24	28	28
5	28	28	20	18	32
6	32	18	32	32	22
7	22	30	18	20	18
8	24	32	26	22	24
9	24	32	26	20	18
10	22	28	32	30	28
11	28	18	22	24	22
12	26	30	28	22	30
13	20	22	30	32	24
14	18	24	20	28	26
15	30	20	24	18	20
16	32	26	18	26	32

FIGURE 3

PSEUDORANDOM DESIRED TO UNDESIRED SIGNAL RATIOS

In practice, an observer would be one of a group of three at a distance of four to six picture heights from the receiver being observed. The receiver would have been adjusted optimally in the opinion of the person conducting the tests. Room lighting was at a somewhat lower level than that which may be typical for television viewing, but there was adequate light for the observer to follow and mark the test sheet. Care was taken to avoid reflections of room lights on the picture tube of a receiver being observed.

A given test condition would typically be conducted as follows:

"This is Test 3."

(Five second pause.)

"The reference condition."

(Two second pause.)

"Test 3."

(Five second pause.)

"This ends Test 3."

(Switch back to reference condition.)

It took about one hour for each group of three observers to view five receivers, one at a time. An observer would usually participate only once a day and would have a rest break about half-way through the hour.

Data were not taken during commercials on the desired TV signal in order to avoid possible confusion and anxiety because of the rapid changes of video material which often occur during commercials.

DATA TABLE AND GRAPHS

A calculator program was written to put the data in order from the pseudorandom sequence in which it was taken. The data are summarized in Table 1, which was used for the graphs, Figures 4 through 6. Figure 4 is plotted in a manner which is somewhat analogous to one of the methods used by the Television Allocations Study Organization (TASO). The ordinate values are desired to undesired signal ratios, with the abscissa values being percentages of the total number of observations at a given desired to undesired signal ratio judged not "worse than" the reference condition. That is, the percentages were calculated with the sums of "equal to" and "better than" judgements.

Figures 5 and 6 for 10,010 Hz offset and zero offset, respectively, show the percentages of observations judging the "test" display quality to be equal to, better than, and worse than that resulting with the reference interference condition. These percentages are plotted versus desired to undesired signal ratios.

TABLE 1

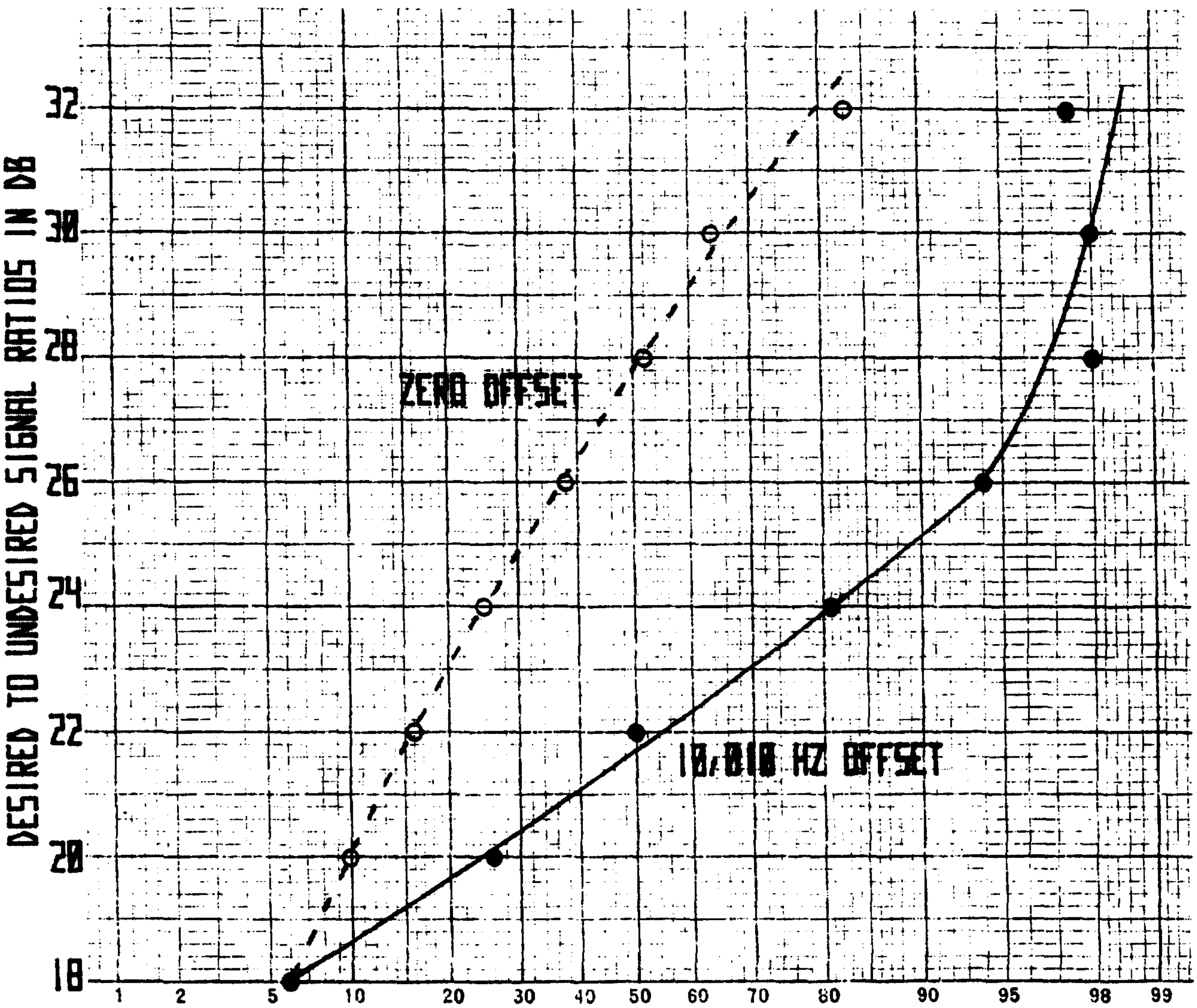
SUMMARY OF DATA FOR
ALL OBSERVERS AND RECEIVERS

A. 10,010 Hz offset compared to reference (10,040 Hz at 28 dB)

Des'd to Undes'd Signal Ratio	No. of Observations: Worse than Reference	Equal to Reference	Better than Reference	"Equal" + "Better" (Not "Worse")
18 dB	392 (94.2%)	20 (4.8%)	4 (1%)	5.8%
20 dB	321 (77.2%)	81 (19.5%)	14 (3.4%)	22.8%
22 dB	208 (50%)	162 (38.9%)	46 (11.1%)	50%
24 dB	80 (19.2%)	225 (54.1%)	111 (26.7%)	80.8%
26 dB	25 (6%)	190 (45.7%)	201 (48.3%)	94%
28 dB	8 (1.9%)	111 (26.7%)	297 (71.4%)	98.1%
30 dB	8 (1.9%)	92 (22.1%)	316 (76%)	98.1%
32 dB	11 (2.6%)	53 (12.7%)	352 (84.6%)	97.4%

B. Zero Hz offset compared to reference (10,040 Hz at 28 dB)

Des'd to Undes'd Signal Ratio	No. of Observations: Worse than Reference	Equal to Reference	Better than Reference	"Equal" + "Better" (Not "Worse")
18 dB	390 (94%)	16 (3.9%)	9 (2.2%)	6%
20 dB	375 (90.1%)	26 (6.2%)	15 (3.6%)	9.9%
22 dB	349 (83.9%)	46 (11.1%)	21 (5%)	16.1%
24 dB	311 (74.8%)	57 (13.7%)	48 (11.5%)	25.2%
26 dB	259 (62.3%)	86 (20.7%)	71 (17.1%)	37.7%
28 dB	199 (47.8%)	120 (28.8%)	97 (23.3%)	52.2%
30 dB	148 (35.6%)	139 (33.4%)	129 (31%)	64.4%
32 dB	70 (16.8%)	133 (32%)	213 (51.2%)	83.2%



PERCENTAGE OF OBSERVATIONS JUDGED NOT 'WORSE THAN' THE REFERENCE CONDITION (10,040 HZ OFFSET, 28 DB RATIO)

FIGURE 4

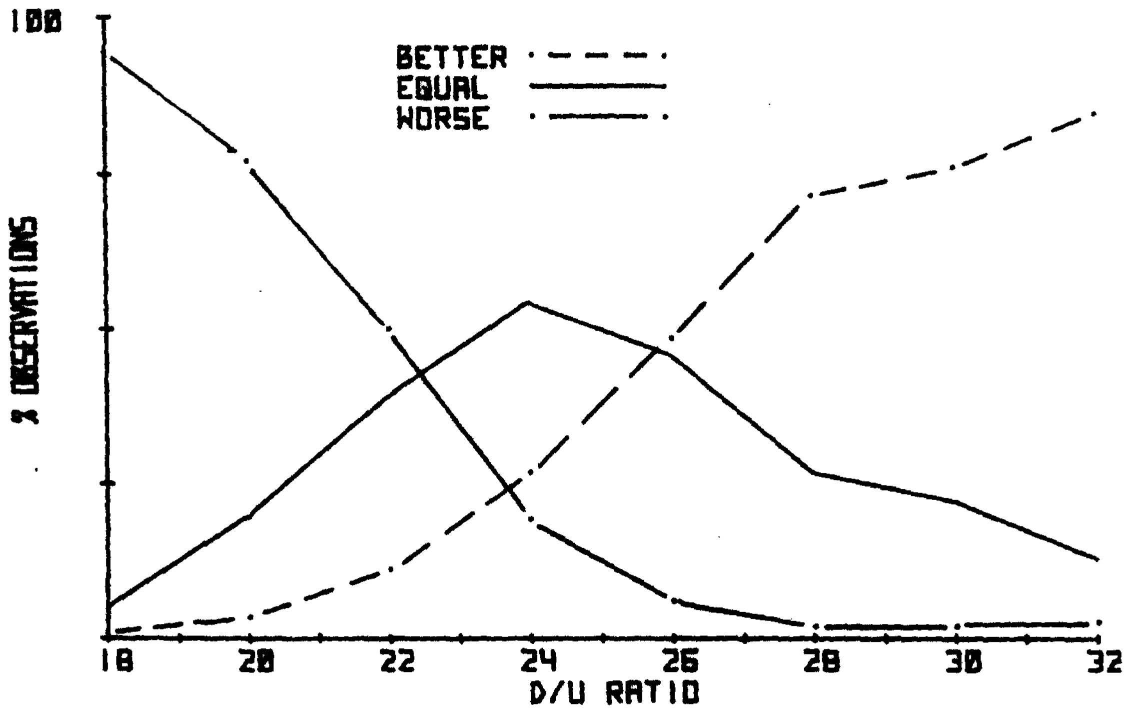


Fig. 5. 10,010 Hz offset compared to reference (10,040 Hz offset 28 dB)

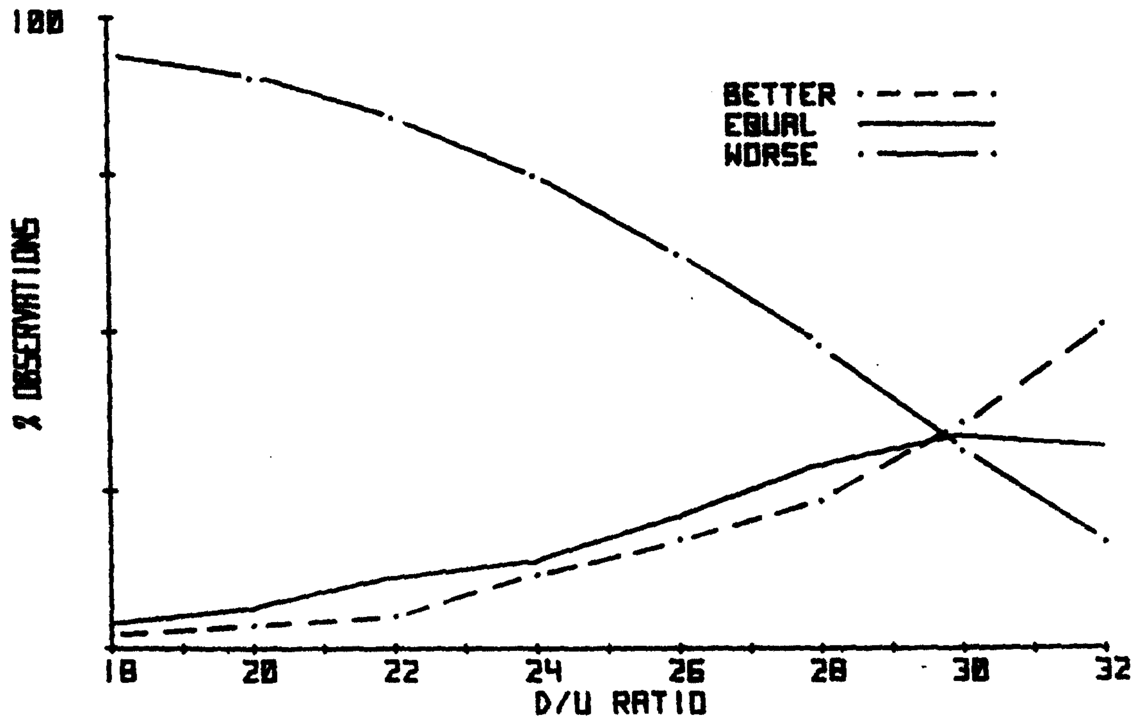


Fig. 6. Zero Hz offset compared to reference (10,040 Hz offset 28 dB)

Note that the data are available for sorting according to individual receivers and individual observers. By this means, members in consistent disagreement with the aggregate can be identified. Because of the large number of observations, removal of such members from the aggregate would probably not have significant impact. However, the identification of such members could be useful in assessing the representativeness of the group of receivers and the group of people.

DISCUSSION

10,010 Hz Offset

The data for precise offset at 10,010 Hz tend to support those of previous studies. For example, in a letter to Chief, Research and Standards Division from Mr. H. Ando, Senior Research Engineer of Japan Broadcasting Corporation, March 31, 1976, the protection ratio for precise offset at 10,010 Hz is quoted as 20 dB under conditions which seem to be analogous to our tests which indicate 22 dB for 50% of the observations, Figure 4.

A Laboratory Division Project, "Offset Frequencies for TV Emissions," Project No. 2229-26, 1956, indicated a 7 dB improvement in desired to undesired signal ratios for a least visible compared to a most visible offset condition at nominal 10 kHz. The resultant 21 dB agrees well with Figure 4 of this report, which infers that a 22 dB desired to undesired signal ratio for precise 10,010 Hz offset results in picture quality comparable to that obtained with a 28 dB ratio in non precise operation.

Also in agreement is a report from RCA supporting a 21 dB ratio for precise offset, "The Application of Very Precise Frequency Control - - -," Wendell C. Morrison, Broadcast News, April and August, 1958.

During the demonstrations of the effects of co-channel television signals at the Laboratory for interested members of the staff on May 7, 1976, the existence of a secondary interference pattern, noted in the previous Laboratory studies of offset visual carriers (Lab Project 2229-26), was observed on some receivers. It consisted of some 20 stationary horizontal bars, becoming more apparent as the level of the undesired signal, offset at 10,010 Hz, was increased. This pattern may be attributed to the third harmonic of the offset frequency, and the second harmonic of the horizontal scanning frequency, producing an integral multiple of the vertical scanning frequency. That is,

$$3\ f_{offset} = 3\ (10{,}010) = 30{,}030\ \text{Hz}$$

$$2\ f_H = 2\ (15{,}734.28)$$

$$= 31{,}468.56\ \text{Hz}$$

$$\frac{2\ f_H - 3\ f_{offset}}{f_v} = \frac{1438.56}{59.94} = 24$$

This effect, accounted for in the data by the reaction of the observers to it, seemed to be the limiting factor for judgements of interference on receivers particularly susceptible to this effect.

Another point to keep in mind is that these data were obtained with only one undesired co-channel signal. Work at the Laboratory in 1956 in conjunction with Project No. 2229-26, "Offset Frequencies for TV Emissions," indicated that additional protection of the order of 4 dB is needed when an additional co-channel signal is present with a precise offset of 10,010 Hz from the desired signal and 20,020 Hz from the other undesired co-channel signal.*

It is emphasized here that the data were obtained with two sources of different video modulation but synchronized, for all practical purposes, with regard to color burst frequency, horizontal scanning frequency, and vertical scanning frequency. This is important because video modulation effects, particularly the edges of the undesired picture, may be made more apparent without synchronization, resulting in "windshield wiper" effects.

Zero Hz Offset

In comparison to the precise offset condition of 10,010 Hz, the zero offset case has apparently not previously undergone rigorous investigation. A memorandum to the Chief Engineer from the Assistant Chief, Laboratory Division, June 18, 1963, states that "---It further appears, from the observations on the several makes of receivers, that the near-zero beat between carriers is even to be preferred over the 10,010 cycle offset when the unwanted picture stands nearly stationary in the background, as it would with the use of color scanning standards on both stations---".

In another memorandum to the Chief Engineer from the Chief, Laboratory Division, January 30, 1964, it is stated that "---While this group was not set up to determine acceptable co-channel signal ratios,it appeared that when there was a 1 cycle or lower offset, and where the color subcarriers were offset 6 cycles or less, a carrier ratio of the order of 30 dB produced very acceptable pictures, probably comparable to 10,010 cycle precise offset---".

The data accumulated for this report do not seem to indicate any advantage of zero offset. (See Table 1 and Figure 4, and compare Figure 5 with Figure 6.) On the contrary, the desired to undesired signal ratio for zero offset, 50% of the observations not "worse than" the reference, is indicated as being comparable to the 28 dB ratio used for the reference condition. The latter represents a "worst case" offset condition assumed under the present standards of operation.

It is apparent from Figures 5 and 6 that the data for zero offset reflect a lack of conciseness and consistency among the judgements of comparative picture quality which is not present in the data for 10,010 Hz offset.

One source of the apparent difficulty in judging the quality of zero offset with respect to the reference condition may have been the significant difference between the visual display of a zero offset condition compared to the reference condition. As described previously, the reference condition has the appearance of stable horizontal bars. However, the zero offset condition has the appearance, when it is visible, of outlines of the undesired picture, typically not framed with the desired picture. The objectionability of this type of presentation may be difficult to relate in a consistent and non-ambiguous manner to the appearance of the reference pattern. On the other hand

* Previous work indicates that 20,020 Hz is as favorable an offset as 10,010 Hz. (Laboratory Project No. 2229-26 and Morrison, loc. cit.)

the 10,010 offset condition is, when visible, similar to the reference condition. Also, the content of the subject material in the undesired picture was obviously more of a factor for the zero offset case than for the 10,010 Hz offset case, particularly since motion in the zero offset picture material affected objectionability.

The visual effect of the zero offset co-channel interference is also related to the relative phases of the horizontal scanning frequency, vertical scanning frequency, color burst frequency, and "synchronization" of the desired and undesired signals. The latter, a pseudorandom variable in our tests, could also occur for off-the-air reception of co-channel zero offset signals.

Another factor to consider is observer bias. The test was conducted under discipline which avoided influence upon the observers' opinions. No information other than the written instructions was initially given. However, simple and non-prejudicial answers were made in response to direct questions from the observers. Also, mention was made of the lack of rightness or wrongness in their opinions, the importance of their individuality as persons, and on the great help all of the data are. The spread of the data indicates that the observers were acting on their own opinions. (Observer bias was not mentioned in connection with the 10,010 Hz offset data, because of the congruence of that data with previous data and the similarity of the appearance of the 10,010 Hz interference, when visible, to the appearance of the reference interference.)

CONCLUSIONS

Precision (10,010 Hz) offset of a co-channel television signal appears to result in displayed picture quality equal to or better than that from a worst case of our present co-channel offset (28 dB desired to undesired signal ratio, 10,040 Hz offset) for 50% of the observations made at a desired to undesired signal ratio of 22 dB. The inference is that a desired to undesired signal ratio of 22 dB could be used in allocations involving a precision offset frequency of 10,010 Hz in cases where a 28 dB ratio has been assumed acceptable for an offset of 10,000 Hz ± 1,000 Hz.

The data for zero hertz offset indicate that this condition offers no advantage, for radiated signals, over the presently used offset of 10,000 Hz ± 1,000 Hz, with respect to co-channel interference.

Because both zero hertz offset and 10,010 Hz offset were tested with effective zero frequency tolerance, an additional advantage of the 10,010 Hz offset case was not documented here; 10,010 Hz offset is less susceptible to degradation for frequency tolerances of the order of a few hertz than is the zero hertz offset condition. The tolerance allowed in Japan for that country's use of precision offset, quoted as 10,010 ± 2.5 Hz, is more liberal than the 1 Hz tolerance estimated for the zero offset case, as quoted earlier in the discussion of zero offset. Advocates of zero offset (synchronous visual carriers) usually suggest a frequency tolerance of $\leq$0.2 Hz.

It is advisable that further studies of precision offset include

1. Studies of low frequency (~360 Hz) very precise offset.
2. Studies of effects with more than one co-channel signal.
3. Studies of acceptable tolerances on offset frequencies, color burst frequencies, and horizontal and vertical scanning frequencies.